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(54) FOUR-WIRE FRACTIONAL WINDING HELICAL ANTENNA AND MANUFACTURING METHOD THEREOF.

(57) A first embodiment relates to a four-wire fractional winding helical antenna characterized in that the characteristics are improved, especially the applicable frequency range is extended and the drawbacks in manufacturing helical conductor patterns are removed by devising antenna shapes, for example, by connecting plural cylinders or circular rods having different diameters in multistage and by forming helical conductor pattern on a cylinder base or multistage cylinder base accurately and easily using photoetching technique. A second embodiment relates to a four-wire fractional winding helical antenna characterized in that a shielding plate is intervened between the four-wire fractional winding helical antenna element and a controlling circuit arranged thereunder. An electromagnetic wave absorbing layer is provided on the side of the shielding plate, surrounding the side surface of the antenna element. Since the shielding plate has an aluminum or copper base and a lamination layer of ferrite thereon, even if the antenna is installed on an aircraft the electromagnetic wave radiated from the antenna body is prevented from reflecting on the antenna base and the aircraft body. Thereby, the shape of the radiation pattern of the antenna can be made more ideal and the degradation of the directional characteristic of the antenna can be prevented.

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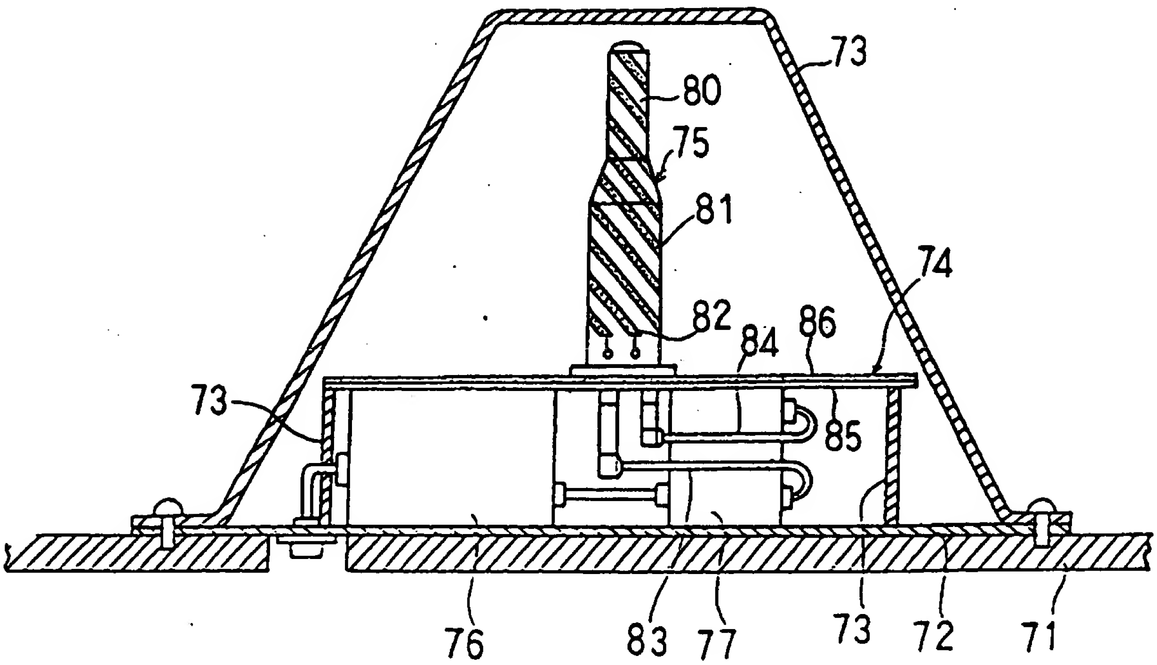

Field of the Invention

The present invention relates to a 4-wire fractional-winding helical antenna whose helical conductors can be formed easily and precisely by the photoetching technology and to the method for manufacturing it. The present invention also relates to a 4-wire fractional-winding helical antenna unit which can prevent the decrease of the gain and the deterioration of the directivity caused by the effect of the reflected wave by the components at the antenna base.

Prior Art

A 4-wire fractional-winding helical antenna has been attracting attention as an antenna used in communication systems using geostationay or non-stationary satellites and is used widely.

Figure 11 is a sectional view showing a 4-wire fractional-winding helical antenna unit heretofore used in such communication systems.

The antenna unit comprises a balun 103 mounted on a base plate 101, an antenna supported above the balun 103 and a hybrid circuit 105 (HYB) located below the base plate 101 and is housed in a radome 102 secured to the base plate 101.

The antenna comprises a mylar member 106 formed in a cylinder and two antenna elements 107 and 108 helically wound around the mylar member 106 as shown in Figure 12. The bottom ends of these antenna elements 107 and 108 are connected to the four terminals of the balun 103.

The balun 103 is a part for an unbalanced-balanced conversion between the hybrid circuit 105 and each antenna element 107, 108, whose bottom terminals are connected to the hybrid circuit 105 by means of a coaxial cable passed through the base plate 101.

The hybrid circuit 105 generates two signals with a predetermined phase difference fed from the signal from a transceiver in an aircraft to send them to the balun 103, and combines the signals fed from the antenna via the balun 103 to send the resultant signal to the transceiver.

However, the frequency bandwidth of the above cylindrical 4-wire fractional-winding antenna 104 is not sufficiently broad for simultaneous transmission and reception through two separate frequency bands with one antenna as shown in Figures 13 (b) and (c).

Figure 13 (a) shows the dimensions of the above single-cylinder 4-wire fractional-winding antenna 104. Figures 13 (b) and (c) show the standing wave ratio (SWR) measured at each of the two input terminals of the balun 105.

The antenna of this example has the dimensions as shown in Figure 13 (a) and its antenna elements (conductor pattern on the side surface of the mylar member) are formed so that the antenna can be used for two frequency bands 1.53 to 1.56 GHz and 1.63 to 1.66 GHz.

The frequency characteristics of the SWRs measured at the two input terminals of the balun are different due to manufacturing errors, variation in the quality of the material and other causes, though it is desired that they are identical.

Since the synthetic characteristic of an antenna is greatly affected by SWR, the upper limit of SWR is generally 1.5 for an antenna being practically usable.

The conventional antenna in Figure 13 (a) is not satisfactory from this aspect, because the SWR of the above conventional antenna exceeds the desirable limit, that is, the SWR in Figure 13 (b) is 2.2 at 1.66 GHz and that in Figure 13 (c) is 1.8 at 1.66 GHz. The conventional 4-wire fractional-winding helical antenna thus has a problem that the frequency bandwidth is not sufficiently broad.

Further, as the spiral antenna elements 107 and 108 are formed by winding narrow strips cut from a metal sheet such as copper around a cylindrical mylar member 106, it takes much time and labor to manufacture the antenna 104, hindering a cost reduction.

Furthermore, since the dimensional accuracy of the antenna 104 is directly affected by the skill of workers, this method for forming the antenna elements is not only suited to a mass production, but also has problems such as a low yield rate of products due to the difficulty in maintaining a uniform dimensional accuracy and a low product value due to a poor appearance.

A possible method to solve the above problems is sticking a copper foil on a cylindrical mylar member 106 and etching it.

With the current etching technique, however, it is difficult to form a required precise pattern on a curved surface.

The formation of a pattern is particularly difficult for the antenna of the present invention described below which has a four fractional-winding antenna pattern formed on the cylindrical surface of a member made of Teflon or other resins with the upper and lower cylindrical parts of different diameters connected by a tapered step surface.

The first object of the present invention is to improve the characteristics of the conventional 4-wire fractional-winding helical antenna, particularly to extend the usable frequency bandwidth and to solve the problems with the formation of the helical conductors. The present invention thereby provides a 4-wire fractional-winding helical antenna whose helical conductors can be formed easily and precisely on a cylindrical or stepped cylindrical member and method for manufacturing it.

When a 4-wire fractional-winding helical antenna is installed on an airframe 100 of an aircraft as shown in Figure 14, the gain in the perpendicular direction of the radiation pattern lowers as shown in Figure 15 to cause the deterioration of the directional pattern of the whole antenna unit. The gain varies according to the direction and Figure 15 shows the maximum gain with an outer line and the minimum gain with an inner line for simplicity. It is known from the diagram that the difference between the inner radiation pattern P1 connecting the minimum gain in each direction and the outer radiation pattern P2 connecting the maximum gain is comparatively large while the gain itself is comparatively small. The cause of the deterioration of the characteristics is thought to be the reflection of a part of the electromagnetic wave radiated from the antenna 104 by the metal base plate 101 and the airframe 100 as shown in Figure 14.

Further, the electromagnetic wave from the antenna enters the balun and the hybrid circuit to interfere with their operation, causing the increase of SWR and the deterioration of the directional pattern which result in the lowering of the antenna efficiency.

Therefore, the second object of the present invention is to provide an antenna unit using a 4-wire fractional-winding helical antenna which can prevent the reflection by the antenna base and the airframe of the electromagnetic wave from the antenna to retain a nearly ideal radiation pattern and thus can prevent the deterioration of the directivity.

DISCLOSURE OF THE INVENTION

To solve the above problems, the 4-wire fractional-winding helical antenna as the first embodiment of the present invention is characterized in that a conductor pattern is formed on the surface of an antenna supporting member made of a cylinder or cylindrical tube or a stepped cylinder or cylindrical tube with a plurality of cylinders or cylindrical tubes of different diameters connected coaxially, and the supporting member has tapered surfaces connecting the surfaces of the cylinders or cylindrical tubes or the top end portion of the supporting member is tapered.

The method of forming the conductor pattern of a 4-wire fractional-winding helical antenna on the surface of a supporting member made of a cylinder or cylindrical tube or a stepped cylinder or cylindrical tubes with a plurality of cylinders or cylindrical tubes of different diameters connected axially is characterized by depositing a metal layer in a uniform thickness on the surface of the supporting member, applying a photoresist over the metal layer, fitting a mask closely on the supporting member and removing the mask after exposing the photoresist to light through transparent parts in the form of a conductor pattern of the mask, and removing unexposed photoresist and then the metal layer under the unexposed photoresist.

The mask for forming the conductor pattern of a 4-wire fractional-winding helical antenna is a tubular case which has transparent helical pattern formed in an opaque ground and fits closely to the surface of the supporting member.

The antenna unit as the second embodiment of the present invention is characterized in that a shield plate is displaced between a 4-wire fractional-winding helical antenna and coupling and conversion circuits, the shield plate is made of aluminum or copper, and the antenna-side of the shield plate is coated with a wave absorbing material such as ferrite.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of an embodiment of the 4-wire fractional-winding helical antenna of the present invention.

Figures 2 (a), (b) and (c) show the dimensions of the 4-wire fractional-winding helical antenna of the embodiment and the result of measurement.

Figure 3 (a), (b) and (c) show the dimensions of an antenna with a short tapered surface at the top end portion and its characteristic.

Figure 4 (a), (b) and (c) show the dimension of an antenna with a larger tapered surface at the top end portion and its characteristic.

Figure 5 (a), (b) and (c) show dimensions of an antenna with a single cylinder or cylindrical tube the overall length of which being slightly tapered and its characteristic.

Figure 6 shows the frequency characteristic of the gain and the ratio-to-axis of the embodiments of the 4-wire fractional-winding helical antenna of the present invention.

Figure 7 shows a mask used for putting the method of the present invention into practice and the method for forming a conductor pattern with the mask.

Figure 8 is a cross-section of a 4-wire fractional-winding helical antenna unit of the present invention.

Figure 9 is a perspective view of the antenna unit shown in FIG 8.

Figure 10 is the radiation pattern of the 4-wire fractional-winding helical antenna unit of the present invention.

Figure 11 is a cross-section of a conventional 4-wire fractional-winding helical antenna unit.

Figure 12 is a perspective view of a conventional 4-wire fractional-winding helical antenna.

Figures 13 (a), (b) and (c) show dimensions of a conventional straight-cylinder 4-wire fractional-

winding helical antenna and the SWRs measured at the two input-side terminals of a balun.

Figure 14 is a cross-section of an example of a conventional 4-wire fractional-winding helical antenna unit.

Figure 15 is the radiation pattern of the 4-wire fractional-winding helical antenna unit shown in Figure 14.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter described in detail are preferred embodiments of the present invention with reference to the drawings.

Figure 1 is a perspective view of the first embodiment of the 4-wire fractional-winding helical antenna of the present invention.

In the embodiment shown in this Figure, 4 conductors of a 4-wire fractional-winding helical antenna are formed around the surface of a mylar member 5 made by coaxially connecting a first cylindrical portion 2 with a tapered portion 1 formed by cutting the corner around the top end, a second cylindrical portion 3 of a greater diameter, and a second tapered portion 4 between the cylindrical portions 2 and 3. This embodiment is characterized in that the supporting member has the two cylinder portions of different diameters connected coaxially in a stepped cylinder and has tapered portions at the top and between the two cylindrical portions. Although the reason is not yet completely elucidated in detail, the antenna of this embodiment has a broader band width than the conventional 4-wire fractional-winding helical antenna.

Figures 2 (a), (b) and (c) show the dimensions and measured results of the first embodiment. The diameters of the upper and lower cylindrical portions 2 and 3 are 20 mm and 25 mm respectively and other dimensions are as shown in Figure (a). Further, the conductor pattern is so formed that SWRs are equal to or smaller than 1.5 over the frequency bands of 1.53 to 1.56 GHz and 1.63 to 1.66 GHz. Figures 2 (b) and (c) show the frequency characteristic of the VSWRs measured at the two input terminals of the balun. By comparing the characteristics in Figures 2 (b) and (c) with those of a conventional antenna shown in Figures 13 (b) and (c), an improvement of the characteristic of this embodiment is noticeable.

That is, the SWRs in Figures 2 (b) and (c) are both below 1.5 throughout the desired frequency ranges.

Not only the form as shown in Figure 1 but also other various modified forms have a similar effect of improving the characteristics.

For example, the antenna shown in Figure 3 (a) has a comparatively short tapered portion formed only at the top end, which has the characteristics shown in Figures 3 (b) and (c). The characteristics are improved as compared with those of the conventional antenna, though the characteristic in Figure 3 (b) is slightly deteriorated at the upper limit frequency.

The antenna shown in Figure 4 (a) has the same form as the above antenna with a tapered portion extended longer. This antenna has the characteristics shown in Figures 4 (b) and (c) similar to those in Figure 3.

Further, the antenna shown in Figure 5 (a) has a cylinder or cylindrical tube slightly tapered over the whole length. A general improvement is also noticeable in the characters of this form of antenna as shown in Figures (b) and (c), as compared with those of the conventional antenna.

The characteristics shown in (b) and (c) of Figures 3, 4 and 5 are also the SWRs measured at the two input terminals of the balun, as those in Figure 2.

The frequency characteristic of the gain and that of the ratio-to-axis of the above embodiments of the 4-wire fractional-winding helical antenna of the present invention are shown in Figure 6 for reference. To make it easy to compare with the characteristic of a conventional antenna, that of the conventional cylinder antenna in Figures 12 and 13 is also shown.

A significant improvement in the gain is also noticeable from Figure 6.

Although an embodiment of two cylinders or cylindrical tubes of different diameters connected is shown in the above description, the present invention is not limited to that embodiment, but three or more cylinders or cylindrical tubes of gradually increased different diameters may also be connected. Further, the members as shown in Figures 4 and 5 may be connected.

As other dimensions other than those shown in Figures are dependent on the characters of the supporting material (dielectric constant, etc.), they are appropriately determined so that the characteristics of the antenna become desirable over the intended frequency bands.

Next described is the method for forming the conductor pattern on the surface of the cylinder or cylindrical tube of the 4-wire fractional-winding helical antenna described above and other forms of the supporting member.

Figure 7 shows a mask used for putting the method of the present invention into practice and the method of forming the conductor pattern using the mask. The mask 64 shown is for forming the helical antenna pattern on the side surface of a Teflon stepped cylinder (antenna supporting member) 61 with cylindrical portions of different outer

diameters.

The mask 64 is in the form of a sheath 65 whose inner surface fits closely to the outer surface of the stepped cylindrical member 61. The sheath 65 is made of a transparent thin sheet such as resins. The larger-diameter bottom end of the sheath 65 is opened so that the mask can be fitted on the stepped cylindrical member 61 by simply putting the mask on the member 61 from the top end as shown in Figure 7. The sheath 65 has helical transparent parts 67 corresponding to the antenna pattern to be formed on the outer surface of the stepped cylinder 61 left in the opaque ground 66.

When forming the conductors in the top end of the cylindrical member, transparent parts 67b are formed in the top end of the mask with one of them broken to form a gap to pass the other. The top end of the sheath 65 may be opened.

The process of forming an antenna pattern using the above mask 64 is as follows.

First, the surface of the Teflon stepped cylinder 61 is roughed with a chemical agent. This roughing of the surface of the member 61 is to increase the adhesion strength of a metal layer formed at the next step. Next, a metal layer is formed uniformly on the surface of the member 61 by evaporation or electroless plating and a photoresist is applied to the metal layer in a darkroom. Then the mask 64 is fitted on the member 61.

While rotating the member 61 along with the mask 64, the photoresist is irradiated with the light to which it is sensitive. The photoresist under the transparent parts 67 is thereby exposed to the light and cures. The exposure may also be carried out without rotating the member 61 by irradiating light from all around the member 61.

Next, the mask 64 is removed from the member 61. Then unexposed photoresist is removed with a chemical agent such as hypo (sodium thiosulfate) and further the metal layer under the removed unexposed photoresist is removed by an etching agent.

Finally, the exposed and cured photoresist is washed out to uncover the metal layer left in the form of the antenna pattern.

This etching process thus can form the antenna pattern easily and very precisely on a stepped cylindrical member and hence makes a mass production with a reduced cost possible.

Further, this etching method using the above mask can be applied not only to a stepped cylinder but also to cylinder, cone, and other solid bodies. To any solid body, this etching process can be carried out easily by making a mask in the form of a sheath which fits closely to the outer surface of the supporting member.

Therefore, it should be understood that the word "cylinder" used in the claim is a concept including not only cylinder but also stepped cylinder, prism, cone, and other solid bodies.

A preferable method for making the mask is cutting a resin sheet into the developed shape of the mask, making the ground 66 opaque leaving transparent parts 67 corresponding to the antenna pattern, and then forming the sheet into a sheath 65.

The sheath may be further hot-molded using a mold in the same form as the supporting member 61 to make the sheath fit closely to the supporting member 61 as those with tapered portions.

Since the 4-wire fractional-winding helical antenna of the first embodiment of the present invention has a usable broader frequency bands, it makes easy simultaneous transmission and reception through distant frequency bands with one antenna.

Furthermore, as the conductor pattern required for the above 4-wire fractional-winding helical antenna of the present invention can be formed easily and very precisely on the surface of cylinder, cylindrical tube, and particularly a stepped cylinder of gradually increased different diameters by the method of the present invention, the method is very effective for a mass production with a reduced cost of the 4-wire fractional-winding helical antenna of the present invention.

Figure 8 shows a cross section of an antenna unit as the second embodiment of the present invention. Figure 9 is the perspective view of the antenna unit.

This antenna unit is so constructed as to be fixed to the airframe 71 of an aircraft and comprises an aluminum base plate 72, a shield plate 74 supported on members 73 perpendicular to the base plate 72 spaced apart from the base plate 72, an antenna 75 mounted on the shield plate 74, and a hybrid circuit (HYB) 76 and a balun 77 disposed on the base plate 72 beneath the shield plate 74.

The antenna body 75 comprises a mylar supporting member 80 and two antenna elements 81 and 82 in the form of narrow strips. The bottom ends of one antenna element are connected to the balun 77 through a semirigid cable 83 and those of the other antenna element are connected to the balun 77 through a semirigid cable 84.

The antenna 75 comprises a supporting member 80 and two antenna elements 81 and 82 in the form of narrow strips wound helically around the supporting member 80. The bottom ends of these antenna elements 81 and 82 are connected to the balun 77 by means of semirigid cables 83 and 84.

The antenna 75 may be the type as shown in Figure 1 and Figure 2 (a). It may also be the type as shown in Figure 3 (a), Figure 4 (a) or Figure 5 (a). It may even be the one with a straight cylinder

shown in Figure 12 and Figure 13 (a).

The shield plate 74 comprises an aluminum plate 85, for example, and a layer of an electromagnetic wave absorbing material 86 such as ferrite coated over the top face of the aluminum plate 85.

Since the shield plate 74 is provided between the antenna 75 and the coupling and conversion circuits such as the hybrid circuit 76 and the balun 77, the electromagnetic wave radiated from the antenna 75 toward the base plate 72 and the airframe 71 in the vicinity of the antenna unit is absorbed by the layer 86 and consequently the bad influence of reflected wave on the directional pattern is significantly reduced.

Further, a conductive plate 85 such as aluminum provides the shielding effect of electric field between the antenna 75 and the coupling and conversion circuits such as the hybrid circuit 76 and the balun 77.

Figure 10 shows the gain in the perpendicular direction of the radiation pattern of the 4-wire fractional-winding helical antenna unit of the present invention. The difference between the inner radiation pattern P1' which connects the minimum value of the gain in each direction and the outer radiation pattern P2' which connects the maximum value of the gain in each direction is smaller and the whole form of the radiation pattern is nearer to a circle compared with that in Figure 15. It is thus known that the radiation characteristics of the antenna unit is significantly improved.

When the transmission signal is output from the transceiver, two signals with a predetermined phase difference are generated from the signal and fed to the balun 77. When the two received signals are output from the balun 77, these signals are combined into one and sent to the transceiver.

The balun 77 is a part for an unbalanced-balanced conversion between the hybrid circuit 76 and the antenna 75.

When the electromagnetic wave from the antenna mixes with the signals in the hybrid circuit 76 and the balun 77, the function of these circuits can be disturbed to cause the increase of SWR and the lowering of the antenna efficiency and hence a deterioration of the directional pattern. However, since the antenna unit of the second embodiment of the present invention has the shield plate 74 provided between the antenna 75 and the circuits 75 and 76, the electromagnetic wave radiated toward the antenna base and the airframe is absorbed by the shield plate 74 and the above problem is prevented.

As described above, the second embodiment of the present invention can prevent the deterioration of the directional pattern caused by a part of the electromagnetic wave radiated from the antenna being reflected by the components at the antenna base and the airframe and the lowering of the antenna performance caused by the electromagnetic wave mixing with the signals in the circuits at the antenna base.

Claims

1. A 4-wire fractional-winding helical antenna characterized in that cylindrical tubes or cylinders of different diameters are coaxially connected into a stepped member and a conductor pattern is formed on the surface of the member.

2. A 4-wire fractional-winding helical antenna in claim 1, in which said member has one or more tapered portions between said cylindrical tubes or cylinders connecting their cylindrical surfaces.

3. A 4-wire fractional-winding helical antenna in claim 1 or 2, in which said member has the corner around the top end cut to form a tapered portion.

4. A mask for forming a pattern of the 4-wire fractional-winding helical antenna characterized by that the mask is a transparent sheet in the form of a sheath fitting closely to the outer surface of the dielectric supporting member and has helical opaque parts formed in the transparent sheet.

5. A method for forming the pattern of the 4-wire fractional-winding helical antenna with a cylindrical tube or cylinder or cylindrical tubes or cylinders of different diameters coaxially connected, comprising the following steps:

   forming a metal layer over the surface of said cylindrical tube or cylinder in a substantially uniform thickness;

   Applying a photoresist to the metal layer and putting said mask on closely;

   Irradiating over said mask with light and removing the mask; and

   Removing unexposed photoresist and then the metal layer under the removed unexposed photoresist to leave the conductor pattern corresponding to the form of the transparent parts.

6. An 4-wire fractional-winding helical antenna unit characterized in that a shield plate is provided between a 4-wire fractional-winding helical antenna and coupling and conversion circuits and the antenna-side face of the shield plate is provided with a layer of a material for

absorbing electromagnetic wave.

7. An 4-wire fractional-winding helical antenna unit in claim 6, in which said 4-wire fractional-winding helical antenna has a conductor pattern formed on the surface of cylindrical tubes or cylinders of different diameters coaxially connected into a stepped member.

8. A 4-wire fractional-winding helical antenna unit in claim 7, in which said member has one or more tapered portions between said cylindrical tubes or cylinders connecting their cylindrical surfaces.

9. A 4-wire fractional-winding helical antenna unit in claim (7) or (8), in which said member of said antenna has the corner around the top end cut to form a tapered portion.

10. An 4-wire fractional-winding helical antenna unit in any one of claims 6 to 9, in which said shield plate comprises an aluminum or copper plate and a layer formed on the antenna-side face of said aluminum or copper plate.

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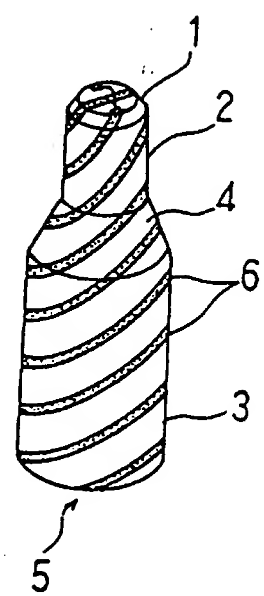

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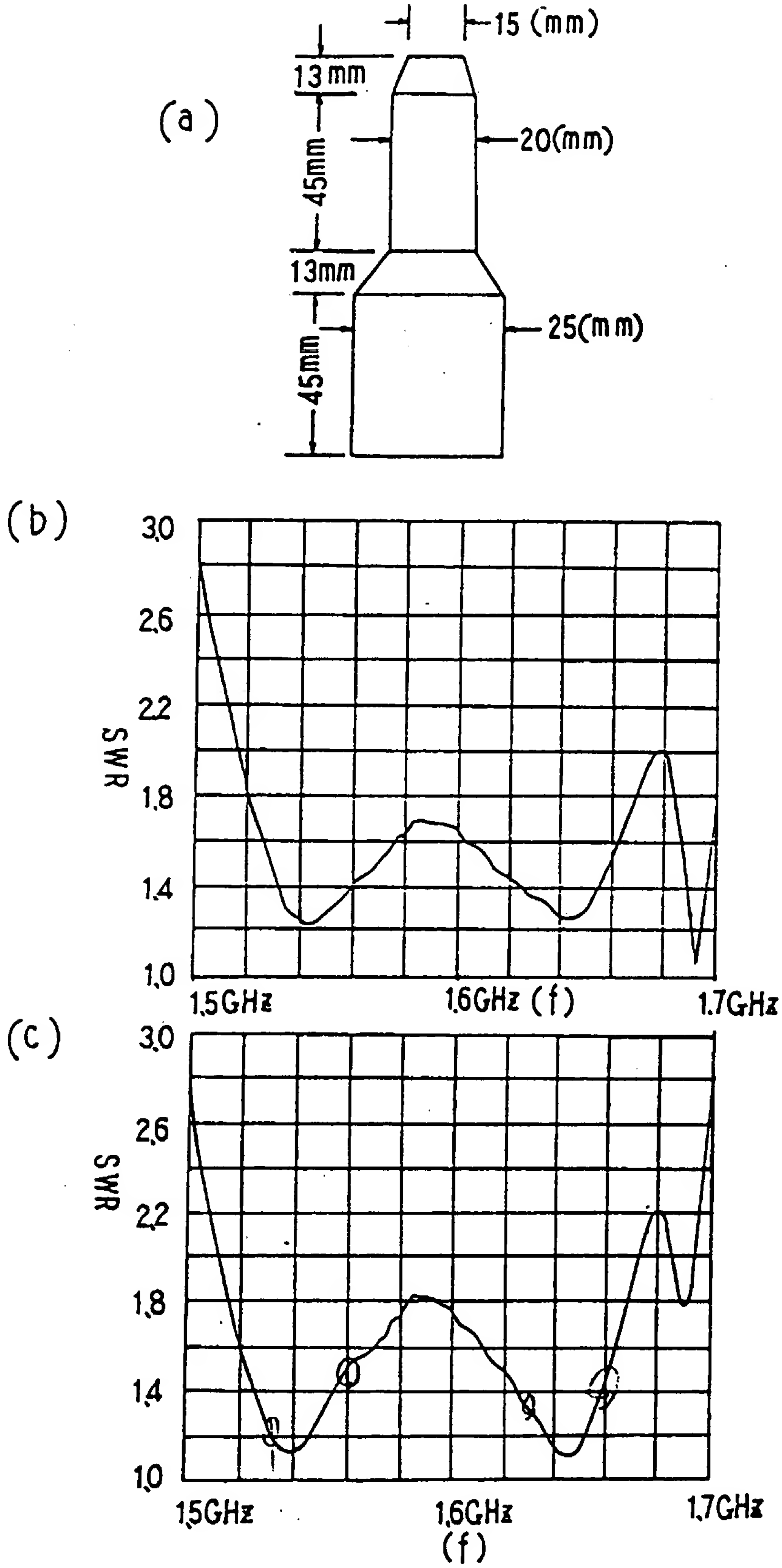
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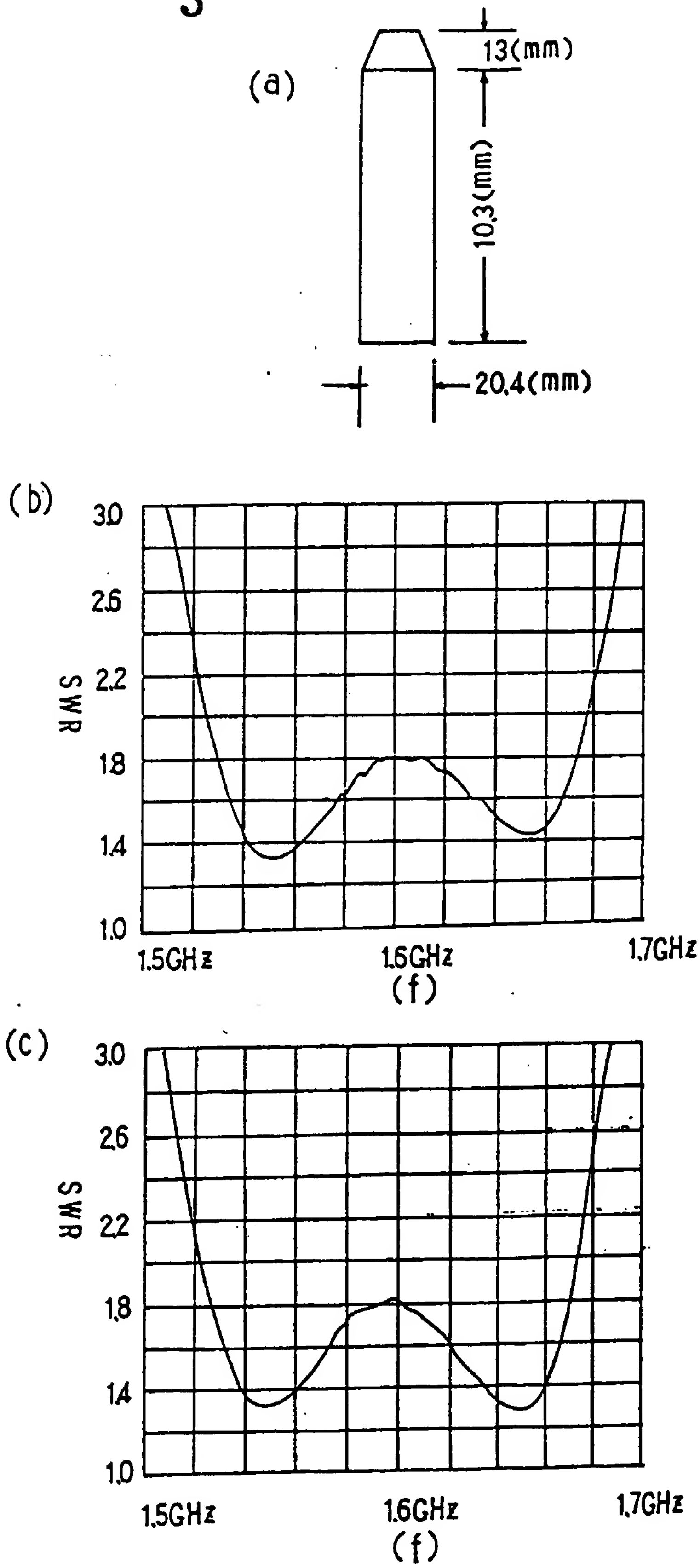
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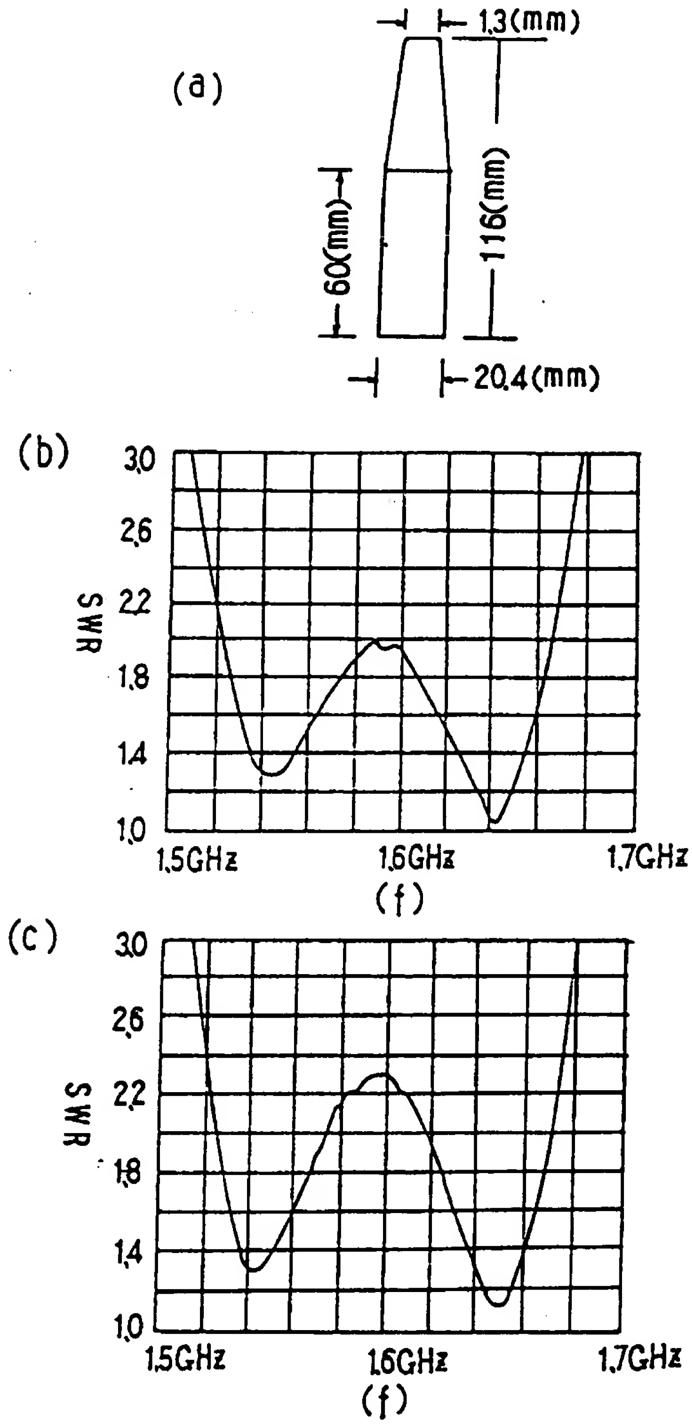
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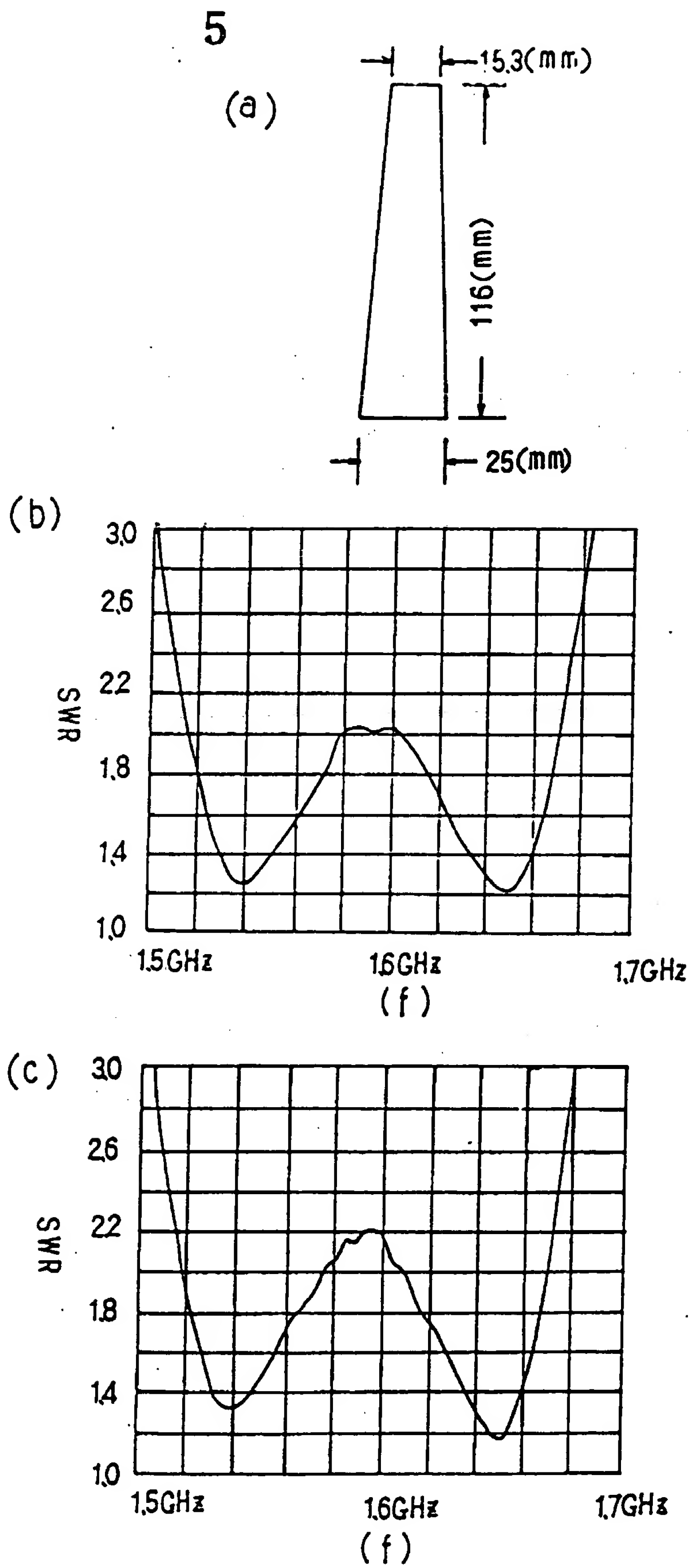
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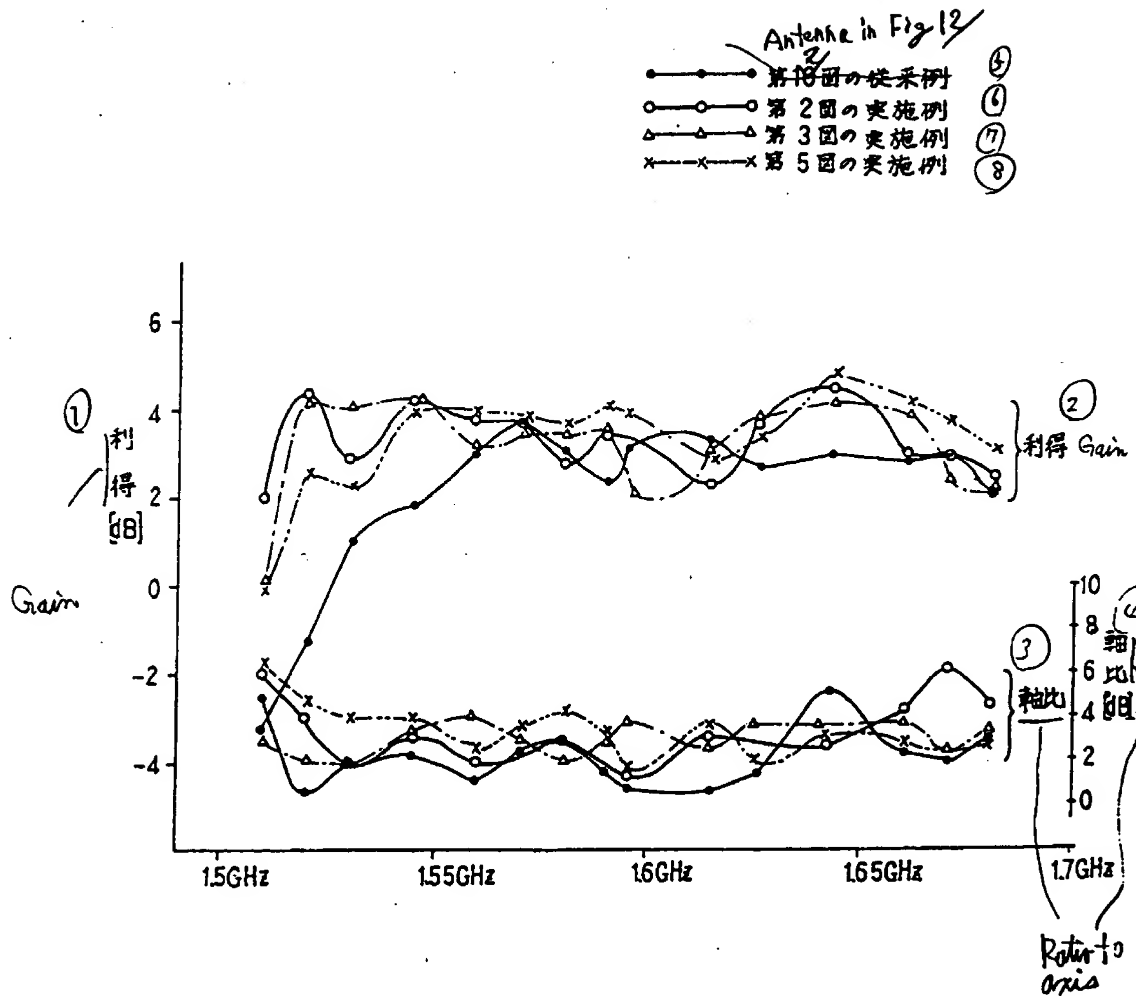
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第3図の実施例 7
第5図の実施例 8
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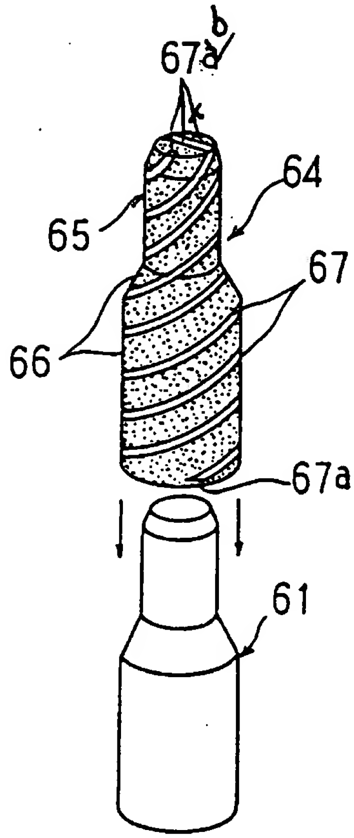

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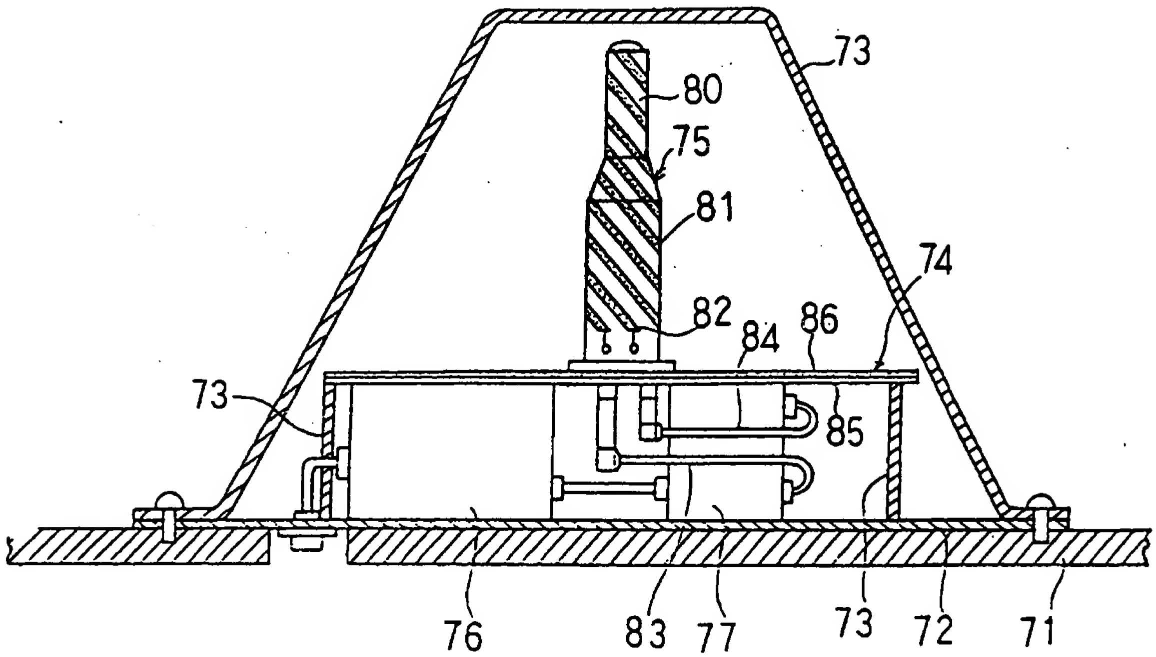

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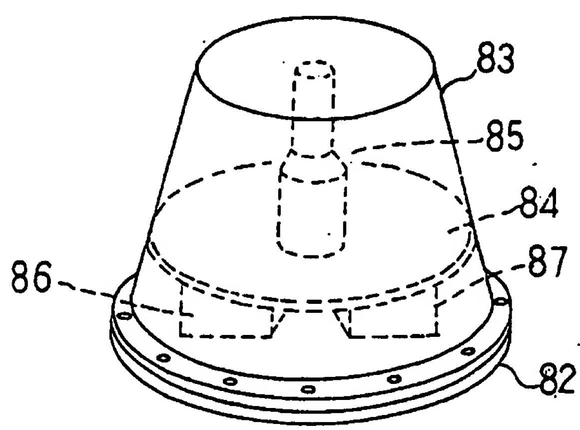

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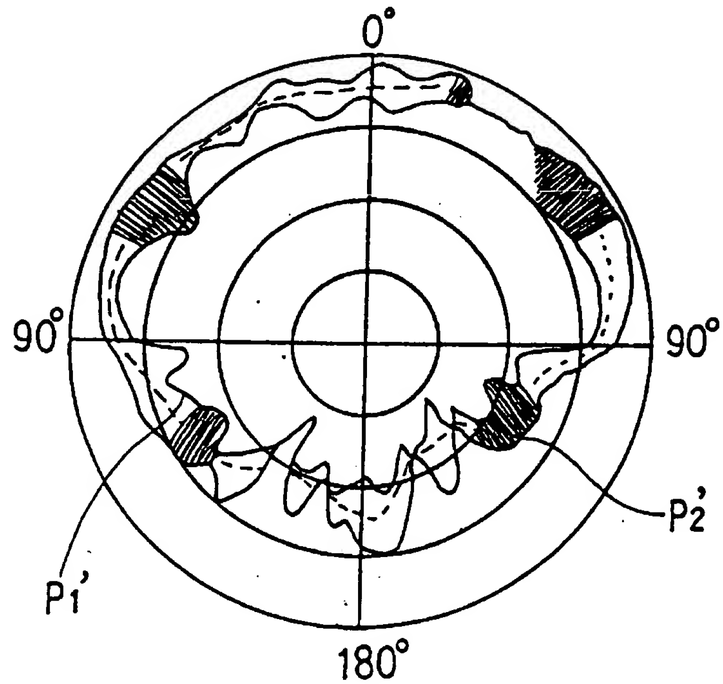

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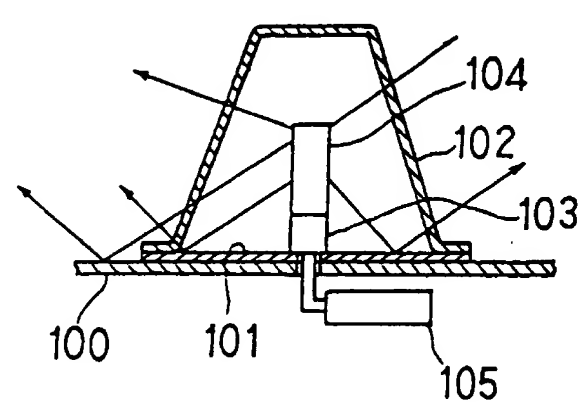

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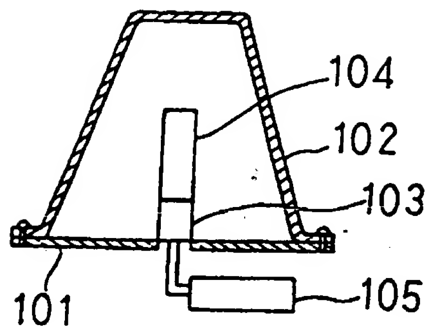

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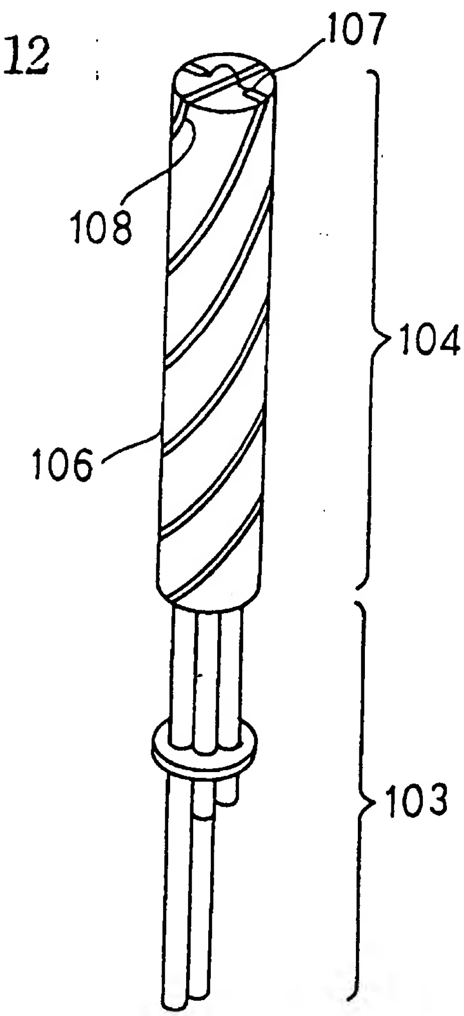

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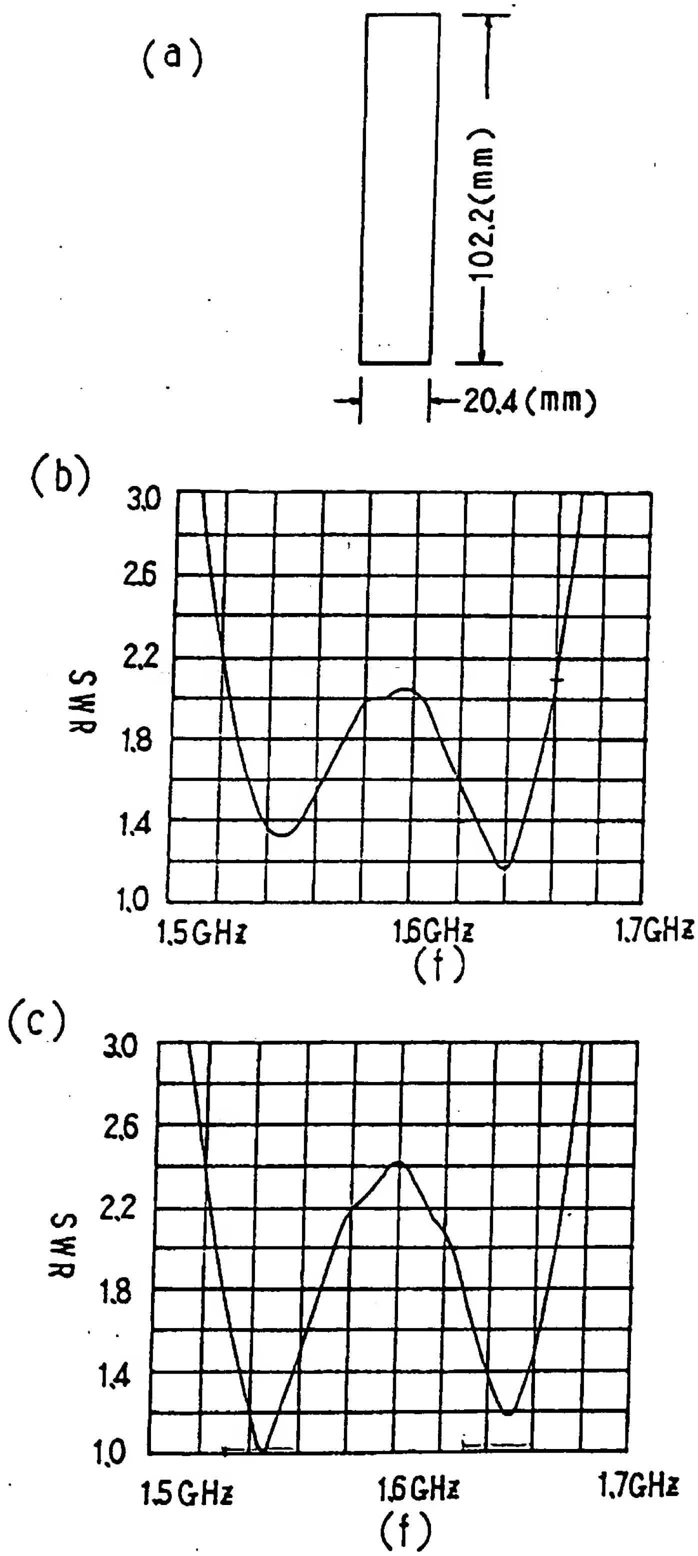
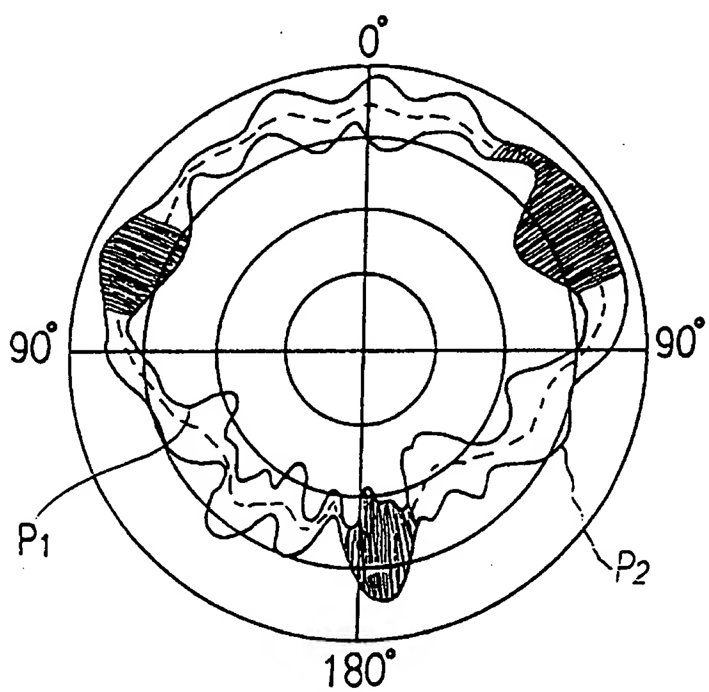

(a)
102.2 (mm)
20.4 (mm)
(b)
3.0
2.6
2.2
1.8
1.4
1.0
SWR
1.5GHz
1.6GHz
1.7GHz
(f)
(c)
3.0
2.6
2.2
1.8
1.4
1.0
SWR
1.5GHz
1.6GHz
1.7GHz
(f)

15



INTERNATIONAL SEARCH REPORT

International Application No. PCT/JP90/01650

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^5 H01Q11/08

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	H01Q1/28, 1/30, 1/36, 11/08

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1951 - 1990
Kokai Jitsuyo Shinan Koho	1971 - 1990

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	JP, B1, 41-849 (Sumitomo Electric Industries, Ltd.), January 27, 1966 (27. 01. 66), Drawing, (Family: none)	1, 6, 7
Y	JP, A, 57-99006 (NEC Corp.), June 19, 1982 (19. 06. 82), Full descriptions, Figs. 3 to 7 (Family: none)	1, 6, 7
Y	JP, A, 59-141802 (Geophysical Survey Systems, Inc.), August 14, 1984 (14. 08. 84), Lines 3 to 17, columns 16 to 18 & EP, A2, 115270 & US, A, 4506267	6, 7, 10
A	JP, A, 54-97353 (Mitsubishi Electric Corp.), August 1, 1979 (01. 08. 79), Full descriptions, Fig. 1 (Family: none)	2, 3, 8, 9

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
February 28, 1991 (28. 02. 91)	March 11, 1991 (11. 03. 91)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

International Application No. PCT/JP90/01650

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	JP, A, 57-99006 (NEC Corp.), June 19, 1982 (19. 06. 82), Full descriptions, Figs. 3 to 7 (Family: none)	4, 5

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.